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Great Lakes
Focus On Water Quality
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TOPIC OF ANNUAL MEETING -- HAZARDOUS SUBSTANCES

IJC Annual Meeting in progress (Photo by Yvan Gagné)

At the International Joint Commission's Annual Meeting on Great Lakes Water Quality, held in Toronto November 12-13, most of the reporting sessions dealt with some aspect of the toxic and hazardous substances issue.

Biological indicators

The Great Lakes Water Quality Board reported during the first day on several points regarding toxic substances in the ecosystem. There is a continued decline of PCB's, DDT and DDE in fish and gull populations throughout the Great Lakes Basin. Likely, the decline indicates decreased exposure of the biological community to toxics. However, as capability to discover undetected substances improves, new substances will be identified in the water and biota of the Great Lakes. Canadian Board Chairman Dr. Robert Slater told the Commission that "our biggest challenge ... is to be able to place an environmental and human health significance on the substances that we have detected."

The two indicator species which the Board used to record the trends in toxic substances were herring gulls and spottail shiners. The herring gull is used because it occurs throughout the Great Lakes System and permits substantial bioaccummulation and bioconcentration: the spottail shiner because it does not migrate far from its place of birth and is a good indicator of contaminants in a specific locale.

Robert J. Sugarman, Chairman of the United States Section of the Commission, expressed reservations about the use of herring gulls' eggs for reporting toxic substances trends, suggesting caution in interpreting the gull egg data due to the difficulty in demonstrating a direct connection between residue levels in the eggs and the water quality of the area where the eggs are found. Migratory behavior and alternative food sources to fish must also be considered when deciphering trends based on gull egg data.

The Board reported slower rates of decline in toxic substances concentrations in gull eggs and fish from Lake Erie, perhaps due to continued input of contaminant residues into the food chain

Great Lakes Water Quality Board Chairmen (Photo by Yvan Gagné) of that lake. Analysis of sediments from the western basin of Lake Erie during 1979 indicated that the Detroit River was a source of PCB contaminated sediments. Further, mirex at a concentration of up to 20 micrograms per kilogram was detected in samples taken in August of 1979, but samples taken the previous May contained no mirex. Investigations will attempt to pinpoint the source.

Data

Some contaminants are continuing to find their way into the ecosystem. Atmospheric deposition is one likely source. Provision has been made in the revised surveillance framework for jurisdictions to strengthen the monitoring of atmospheric deposition for the sorts of compounds which are of concern in a toxic management program. Better atmospheric deposition data are required for both the formulation and application of control programs. Better data collection, analysis and overall quality assurance procedures for water quality data are also required.

Under the provisions of the 1978 Agreement, and as understanding of data quality needs improves, more time, manpower and money will have to be directed to data management. Otherwise, the Board told the IJC, there are bound to be difficulties with handling and processing the information required to provide worthwhile reports to the Commission.

Waste management

With the advent of new analytical techniques and the seemingly inexhaustible influx of new substances into commerce, past misdeeds as well as new toxic contaminant problems are bound to be discovered. Programs must meet the challenge of controlling atmospheric deposition, direct discharges to the lakes and tributaries, and runoff of toxics placed on land. Other sources of contamination have recently become apparent: leachate from waste sites and the release of in-place toxicants from contaminated sludge and sediments. Thus, as John McGuire, United States Chairman of the Water Quality Board stated, "the management of toxicants has required us to develop programs to deal with three control facets: the effective control of toxic substances currently being emitted to the lakes, the identification and management of various already seriously contaminated areas, and the control of future releases."

The Board asked its Toxic Substances Committee to begin evaluating the effectiveness of toxic substances control programs. The Committee has prepared a model toxic substances management plan and examined legislation now available to implement the model. A report assessing the available legislative mechanisms is expected in April 1981.

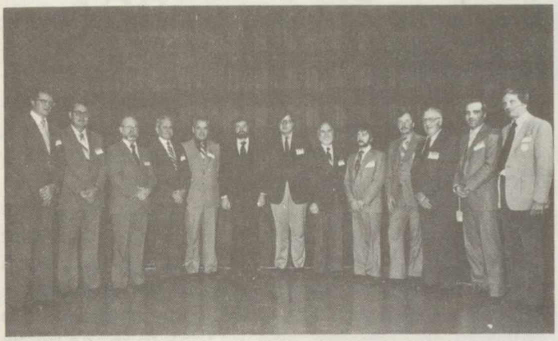
Eugene Seebald of New York State presented another topic relating to hazardous substances. He stated that, "The failure of Governments to recognize the need for an integrated approach in programming to implement any toxic controls has been devastating." The most difficult part of the problem appears to be the question of siting high technology waste handling, treating, reclamation, destruction and disposal facilities. Once siting becomes specific to a location, then the issue becomes emotional. Public education about the problems of properly accommodating wastes in the environment to minimize environmental impacts versus the even greater problems for society if the wastes are not properly disposed of, Mr. Seebald urged, must precede public discussion of siting.

Commissioner Jean Roy asked how it might be possible to reconcile the problems of obtaining public approval for sites with the inability to assure safety. Mr. Seebald responded that he doubted the public would approve totally. Acceptance of certain control mechanisms can be achieved if the public recognizes the full scope of the problem and has more examples of responsible management of toxic wastes by industries, governments and site operators.

Commissioner Jean Hennessey asked about the synergistic effects of contaminants, inquiring whether the 1978 Agreement water quality objectives are sufficient to protect the Great Lakes ecosystem from the combined effects of toxic substances. She pointed to the Niagara River as an example of her concern. Dr. Slater stated that the intensive effort presently underway on the Niagara River to analyze and identify sources of contaminants, and find new sources based on data collected may well assist the IJC in determining the adequacy of the present system of objectives under the Agreement.

Surveillance

After the proposed Great Lakes International Surveillance Plan was presented, Dr. Slater expressed confidence that the plan "will allow for better information on contaminants." Chairman Sugarman questioned whether there is adequate provision in the plan for monitoring of toxic substances in connecting channels and tributaries. Surveillance Work Group members assured him that the plan will monitor toxic substances trends at the mouths of tributaries as well as throughout the Great Lakes waters. Fish and sediments are to be collected and analyzed. If significant problems are identified at the mouth of a tributary,



Great Lakes Water Quality Board Members

then if the jurisdiction(s) involved accepts that the problem is significant, follow-up investigations would be conducted upstream. In addition, the whole lake effort to collect and analyze fish will point to lakewide trends in toxic contaminants. Dr. Donald Mount, United States Chairman of the Science Advisory Board, later commented that, "The emphasis ... is to focus our contaminant program on those substances that form residues in sediment and biota." However, he added, "just because a chemical or a series of chemicals does not form a residue ... does not mean that we are home free and there are no problems ... we do need to measure other things as well."

Data collection

On the second day of the Annual Meeting the Great Lakes Science Advisory Board presented a comprehensive review of the problem of hazardous substances in the Great Lakes Basin Ecosystem. The needed solutions, according to the Board, depend on better and centralized data collection. Without that, improved assessment of human health effects of substances and fuller knowledge of how they reach the ecosystem are not possible.

The Board recommended that the IJC centralize an information system to collect, store, sort and dispense data needed by the jurisdictions for their programs to control hazardous substances.

Atmospheric loading

Like the Water Quality Board, the Science Advisory Board stated that data are not adequate to identify all hazardous chemicals for which atmospheric loading is important. Dr. Stephen Eisenreich, of the University of Minnesota, stated that, "... atmospheric deposition is the primary pathway into the Great Lakes for many trace organics and for a variety of trace elements. Atmospheric transport is a significant pathway for nearly all trace organics and for a variety of trace elements."

Recognizing Dr. Eisenreich's work, the Science Advisory Board recommended that the Commission urge jurisdictions to institute or intensify programs to quantify atmospheric loadings to the Great Lakes.

Waste treatment

The Board told the Commission that unless substances of concern are destroyed during waste treatment there can be no assurance that they will not be discharged into the air, on land or to the water and then do harm to the ecosystem. Members urged that destructive treatments be used and also that every attempt be made to recover hazardous materials for reuse rather than have them remain dangerous wastes. They further suggested that the use and loss of hazardous substances be reduced through changes in industrial processes. The Board also told the Commission that data regarding the discharges and processes are not complete.

Health

The Health Effects Committee of the Science Advisory and Water Quality boards stated that 381 toxic chemicals have been detected in the Great Lakes ecosystem. To be listed, a substance must meet four criteria: detection in the system, evidence of bioaccumulation potential, evidence of toxicity to fish, wildlife or man, and persistence. George Becking, spokesman for the Committee, said that of the substances identified, "there is acute toxicity data in open literature for only 18 chemicals. We have known chronic adverse effects in man for 33 chemicals and ... in experimental animals we have data for another 38. Chronic effects in man are found only at extremely high exposure levels ... there was not evidence to date that there is a health hazard to man from the levels that perhaps are out in the environment." Obviously, there is not enough information from which to do adequate human health hazard evaluations. Such evaluations could be used by the Surveillance Committee to ensure that the chemicals of most concern to man are part of the monitoring program under the Great Lakes International Surveillance Plan.

Scientists today, the Science Advisory Board said, do not know the significance of the effects that chemical residues have on people. Substances that are not food additives or pesticides are not uniformly measured or regulated. Therefore, acceptable levels in fish for human consumption have not been set. Exposure to such residues is high among small groups in the Great Lakes Basin because they eat more fish than most people do. Though the consequences of such exposure are presently unknown, those exposed should know they may be taking a higher

Related IJC Activity

In the Commission's *Seventh Annual Report on Great Lakes Water Quality* to the Governments of Canada and the United States, IJC recommended that "steps be taken to increase public understanding for providing adequate and safe facilities and sites for the handling and disposal of such wastes, including adequate public demonstration that such sites are technically feasible and environmentally safe." IJC also recommended: "the replacement of toxic and hazardous substances in the manufacturing process with less hazardous materials, and the reduction of wastes (through product modification, recycling, closed-loop production systems or neutralization of wastes) be vigorously pursued by industry and governments. As such replacement may not be achieved in the near future, the Commission also recommend(ed) that the Governments ensure that a comprehensive system of waste management be developed and implemented for the safe storage, transportation and disposal of hazardous wastes."

risk than those who do not consume as much fish. The Board urged that exposed populations be identified and informed; cause/effect relationships of such exposures be identified; the tolerance levels for harmful substances be established, and information be collected so that the effects of various levels of hazardous substances can be routinely assessed.

Great Lakes Science Advisory Board Members

Wrap-up

After the Science Advisory Board had completed its presentations, Commissioner Hennessey asked about what she perceived to be a marked difference in the tones of the two reports -- the Water Quality Board presented a rosy picture; the Science Advisory Board, a somewhat gloomy one. Dr. Mount responded that the rosy picture was presented for only about six chemicals. The Science Board agrees that the picture is improving with those particular chemicals, but members want the Commission and the public to know that the job is far from complete.

Dr. Keith Rodgers, Canadian Chairman of the Science Advisory Board, said "One might take some optimism from the fact that we have been able to do something about those six chemicals. We are in kind of a race against the issue. We are still making progress, and we look to those kinds of successes to provide us with confidence we can achieve something. We know we are still in the race. We must keep an eye on the goal ahead -- a healthy ecosystem. Perhaps this Board is suggesting just how much harder we have to run to reach the goal."

BRIEFS

■ Ontario's Ministry of the Environment has hired consultants to begin investigating nearly 50 private waste disposal sites across the province. Only 15 of the sites are operating; the rest are closed. This study supplements an Ontario-wide investigation of 192 old municipal garbage dumps which were identified after a search of historical records and public memory of old waste sites. The original survey found 1,450 sites and marked the 192 as the first group for study. Ontario regulates waste management through the Waste Management Act and the Environmental Protection Act.

■ Three new acid precipitation studies are underway in Ontario, launched by the Ministry of the Environment. The studies are designed to determine economic and social costs and damages caused by acid rain. Actual and potential damage will be measured from three perspectives: in physical units, dollars, and in terms of environmental amenities. When the studies are completed, further control strategies may be justified since the benefits of abatement will be clearly defined.

■ The Canadian Government will spend $41 million between now and 1984 to combat acid rain. The Canadian Cabinet has approved the joint submission of Environment Canada, the Departments of Fisheries and Oceans, and Health and Welfare to launch a comprehensive scientific, engineering and socio-economic research program to design strategies to control acid-causing pollutants, to lessen their adverse effects and to protect the fisheries resource in Canada. The resulting knowledge is also required to substantiate Canada's position in seeking cooperative action from the United States.

AGREEMENT INFORMATION MATERIALS WELL RECEIVED BY PUBLIC

What people think ...

"Everyone on our geography teachers' council in Niagara Falls, Ontario, wants to use the program; we may need a copy for the rest of the school year." J. Mullin - Westlane Secondary School, Niagara Falls, Ontario

"There are so few good programs on the Great Lakes; this one was really needed, especially by marine educators." R. Abrams, President, National Marine Educators Association

"More than 1750 people attended our open house at the Great Lakes Historical Society Museum this month and saw your program." D. Peters, Canadian Consulate-Cleveland, Ohio

"I think it's important for people in Houston (Texas) to know about the Great Lakes and to use the lessons learned through the Great Lakes Water Quality Agreement to help solve the problems in Galveston Bay and the Gulf (of Mexico). The Audubon Society would like to use the program again soon." Dr. D. Marrack, Vice President, Houston Audubon

"The program initiated a really good discussion of local water pollution problems in Simcoe, while giving us a wider perspective on the Great Lakes." C. Lee, Simcoe (Ontario) Composite School and Simcoe Rotary Club

"The program will be used to begin the first meeting of the Great Lakes Pollution Task Force of the Water Pollution Control Federation in Montreal in December." L. Rancourt, EcoResearch, Ltd., Montreal, Quebec

"I read the script myself and stopped to explain the more complicated graphic slides to the students in my sixth grade class at Hammond, Indiana. It was worth it." G. Janigg, Hammond Elementary School

"We felt that it gave an unbiased overview of the pollution problems of the Great Lakes and explained how the International Joint Commission has worked toward solutions to complex problems. We certainly plan to list it as a good resource for teachers." J. Hug, Office of Environmental Education - Columbus, Ohio

"Je serais interesse a visionner une copie de ce diaporama, version francaise." J. Moquin, Alberta Education, Edmonton, Alberta

What it is ...

The comments presented in the adjacent box are from the approximately 10,000 people who have seen "Promises to Keep" or have read the illustrated booklet about The Great Lakes Water Quality Agreement of 1978. These materials were prepared by the staff of the Great Lakes Regional Office to provide citizens of the United States and Canada with clear, concise explanations of the development, purpose, content, and implementation of the Agreement.

Program kits (including script, carousel, and 12 minute narration tape) have been circulated extensively throughout the Great Lakes Basin on both sides of the border, sent around the United States (including excursions to California, Texas, Florida, Virginia, and Maine) and to the Canadian Provinces of Saskatchewan and Quebec. Nineteen long term circulation centers have been established in almost all Great Lakes jurisdictions to make it simpler and faster to deliver the program to those who request it. Many of these centers can also fulfill requests for quantity shipments of the booklet, which are also available from the Great Lakes Regional Office.

Other items in preparation include French versions of the slide/tape program and booklet, a brochure about Toxic Substances and the Great Lakes Water Quality Agreement, and a brochure about Phosphorus and the Agreement.

The flexibility of these materials has been demonstrated by the diversity of those using them to date -- fourth graders in an environmental school in Michigan as well as post graduate university students and Great Lakes research scientists, members of the League of Women Voters, government officials, fishermen and riparians. Many people have requested more information -- bibliographies, reports, publications from other agencies, FOCUS.

What can you use? An information kit for yourself, your family, your class or club? Would you like to schedule a showing of "Promises to Keep"? Would IJC reports help give you a more detailed picture of the progress toward Great Lakes water quality? The information services section of the Great Lakes Regional Office can certainly provide you with these materials, and perhaps more. Please contact Information Services, Great Lakes Regional Office, International Joint Commission, Suite 800 - 100 Ouellette Avenue, Windsor, Ontario N9A 6T3. (519) 256-7821 (Canada); (313) 963-9041 (U.S.)

CHLORINE DISINFECTION

by Robert M. Carlson

Chlorine disinfection practices began in North America in the early part of this century when techniques for the continuous application of chlorine to raw water, first used in England a few years earlier, were applied to the 40 mgd Boonton Reservoir system in Jersey City, New Jersey (1908). This concept was spurred on by the demands of a burgeoning urban society coupled with production capacity stimulated in part by imminent involvement in a World War. The "final" resolution of the issue came when legal objections to chlorine disinfection that were made to stop the introduction of "poisonous" chemicals into drinking water were set aside in a series of court decisions from 1908-1919.

The way was then cleared for chlorine to become what one prominent engineer (White) has called "the most valuable and versatile tool available to the water chemist." Chlorine is now not only used for the disinfection of drinking water, wastewater and swimming pools, but is also very important in sanitary food preparation and the removal of algal growth from cooling water distribution systems. The overall public health benefits from these developments are considered to be firmly documented by the dramatic decrease in the outbreaks of typhoid fever and other water-borne diseases. This success in the control of communicable disease, left only the chronic exposure effects of residual chlorine and chlorinated byproducts in water to be determined.

Initial advances in understanding the chemical implications of chlorine disinfection were associated with the process itself (e.g. Palin's analytical procedure, chloramine demand as originally proposed by Wolman and Enslow, and chloramine chemistry and breakpoint concept as developed by J.C. Morris). However, consideration of the interaction of chlorine with materials other than ammonia present in the water was reserved for the problems that were associated with taste and odor or with acute toxicity. For example, a medicinal taste was associated with certain mono- and di-chlorophenols produced during disinfection and some fish kills were traced to the presence of chloraquiacols generated during chlorine bleaching of wood pulp.

More recently, the advent of improved techniques for trace level chemical analysis delineated a wide variety of organic species that could previously only be categorized into such broad groupings as acids, bases, lipids, carbohydrates, aromatics, etc. This analytical capability rekindled a fundamental interest in the host of possible chlorine (or oxygen) incorporation processes to which these compounds are subjected.

A milestone was soon provided by Robert Jolley (1973) in an experiment using radioactive chlorine and sophisticated separation techniques that were developed at Oak Ridge National Laboratories. This experiment identified over 50 distinct chlorine containing organic compounds including several chlorinated aromatics and nucleic acid fragments. The significance of these results was enhanced by the recognition by Jolley and others that these were many other components (i.e. the volatile and large molecular weight fragments) yet to be identified. However, it was further research that dramatically focused the world's attention on the potential chronic problems of chlorine disinfection processes: and the confirmation of the carcinogenicity of chloroform by the U.S. National Institutes of Health observation of the ubiquity of chloroform and other haloforms in disinfected water by both Rook in the Netherlands and the U.S. Environmental Protection Agency's Laboratory in Cincinnati. Subsequent discussion of the issue rapidly moved from the laboratory to the public arena and the resulting visibility lead to the allocation of more resources to continue and expand the investigation scrutiny.

The results from these new and renewed efforts have now begun to emerge. For example, the presence of haloforms in water subjected to chlorine disinfection has been generally ascribed to the presence of humic and fulvic acids. It has been proposed that these complex decomposition products of plant life contain chemical features that provide an alternative entry into the haloform reaction of methyl ketones. Other studies have suggested that people who consume chlorinated drinking water suffer a higher incidence rate of certain types of cancer, and that the long observed reduction in biological oxygen demand (BOD) is due to the generation of chlorinated organic products that are toxic to the microorganisms used in the test or to the decreased rate of metabolism of these new compounds over the BOD test period. In addition, many laboratories are finding a substantial number of new and unusual chlorinated species as scientists develop a variety of sensitive biological and chemical techniques to probe the disinfected aqueous milieu.

There are several dimensions of disinfection that have yet to be adequately addressed. For example, the wide and unquestioned acceptance of chlorine disinfection almost inevitably has lead to inappropriate and excessive application.

Moreover, the consumer has been confused about expectations for the water produced upon typical chlorine disinfection; many people equate disinfection with the complete removal of viable biological material (e.g. sterilization). This misinterpretation often leads to questions as to why a "totally effective" process needs to be reevaluated and refined. Another dimension involves the development of standards that are more meaningful and precise than the current coliform levels (i.e. the coliform presumptive test). This aspect is particularly important as we consider the development of standards for viral content of potable waters and the apparent inability of present disinfection practices to control outbreaks of water-borne viral diseases (e.g. infectious hepatitis and gastroenteritis).

Within the process portion of chlorine disinfection several areas remain to be evaluated. For example, different "grades" of chlorine are used for disinfection applications. The highest "grade" is used for drinking water. Why then are lower "grades" not suitable for potable water and why are they acceptable for other disinfecting applications? In other words, what impurities does the classification scheme recognize and what are acceptable amounts of these chemicals for the consumer or for a receiving water?

The typical mode of chlorine addition may also be of concern. Dilution of chlorine gas with a portion of the process water under pressure creates conditions of high relative acidity (low pH) and high concentrations of chlorine (high HOCl concentration) that may result in rapid chlorine uptake by organic compounds present in the water. Other process variations such as sludge solubilization or ammonia removal require the use of high doses of chlorine ("superchlorination) to accomplish their respective goals. The generation of significant amounts of carbon bound chlorine by these processes is a foregone conclusion. "Dechlorination," as currently practiced (typically the addition of sulfur dioxide), reduces only the chlorine residue (i.e. the oxidative species of chlorine), and leaves unaffected the majority of chloroorganics previously formed. Significantly however, it has been observed that the reactive organics that interact with SO_2 may represent a substantial contributor to the mutagenic activity of concentrates of organic matter from chlorinated water not treated with SO_2.

Many scientists also find it unsatisfying that many fundamental chemical and biological questions have yet to be satisfactorily answered. For example, the actual chlorinating species responsible for the various products observed during disinfection remains elusive. This amazing gap in our knowledge is due primarily to the presence of a complex equilibrium that exists among a host of reactive chlorine containing species (e.g. Cl_2, ClO^-, Cl_2O, ClO_2^-, ClO_3^-, ClO_4^-.) that vary in concentration over the typical range of conditions used for disinfection. This complexity is magnified by the observation of a significant change in the rate of reaction with a variation in the concentration of ammonia, the presence of particulate matter, or the introduction of sunlight. Also unavailable are substantial data on the influence of amines other than ammonia (e.g. amino acids, peptides, and nucleic acid fragments) on disinfecting capability and chloro-organic production. The biochemical receptor in biological systems that results in toxicity upon disinfection is also not well defined. This fact is less surprising after noting the chemical complexity and the potential for variation in toxicity mechanisms from one target pathogen to another.

The negative aspects of chlorine disinfection that have been raised have lead to increased interest in alternative processes. The disinfectants that are considered most frequently are ozone (O_3), bromine chloride (BrCl), and chlorine dioxide (ClO_2). Permanganate (MnO_4^-), bromine (Br_2), iodine (I_2), hydrogen peroxide (H_2O_2), and ultraviolet light have also been mentioned. Currently, all of these alternatives are more expensive than chlorine, and are considered to be in the development stage or may require the construction of facilities for on-site generation. Among the possible alternatives, ozone has the highest oxidizing capability, as well as the greatest capability for the highest effective bacterial and viral deactivation. However, ozone rapidly decomposes in water (i.e. a half-life of approximately 20 minutes) and cannot, therefore, maintain a residual throughout a distribution system. The organic product distribution from using the major chemical alternatives is as yet not well defined, but both ozone and chlorine dioxide appear to give products that are free of halogen incorporation.

It is clear that history shows that chlorine disinfection of water for the control of water-borne bacterial disease was remarkably effective and, in part, permitted the development of a thriving, urban society. Now, in contrast to many developing societies, we are questioning every aspect of disinfection practice. This reevaluation process is threatening to those who envision a precipitous change in method that may prove to be less desirable than our present course. However, unless some very detrimental new information is forthcoming, chlorine will retain an important position in assuring a supply of high quality potable water. On the other hand, there are clear indications that improvements can and should be made and that engineers and regulatory bodies should be open to the consideration of the options presented. For example, the minimization of oxidative chlorine-organic contact seems obvious and considerable imaginative effort should be directed towards that goal.

Of particular interest in this regard is the recent report ("Alternatives for Managing Chlorine Residuals: A Social and Economic Assessment," April, 1980) of the Chlorine Objective Task Force that was submitted to IJC's Great Lakes Water Quality Board. In this report, the Task Force comes to essentially the same conclusions described above and in general promotes ... "the development of guidelines by the jurisdictions for selection of sites where chlorination requirements can be relaxed without adversely affecting public health" (p.7). This report provides incentive for continuing the investigation of how to provide the best disinfection technology in the most cost-efficient manner.

About the Author
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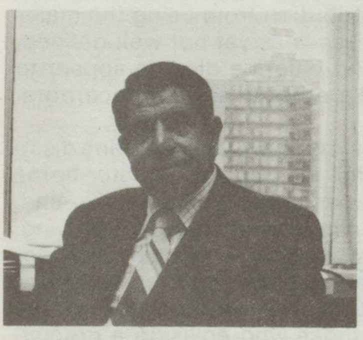
PEOPLE

Three long time members of the Great Lakes Regional Office staff of the IJC recently left Windsor: Ken Oakley - Director of the office since April 1975, Ken Walker - Deputy Director since 1976, and Larry O'Leary - Senior Engineer since 1973.

In other positions are two new staff members: Dr. Clayton Edwards, a fishery biologist most recently with the Federal Energy Regulatory Commission, and Dr. Fahmy K. Fahmy, a toxicologist who left Beak Consultants to join the IJC Windsor staff.

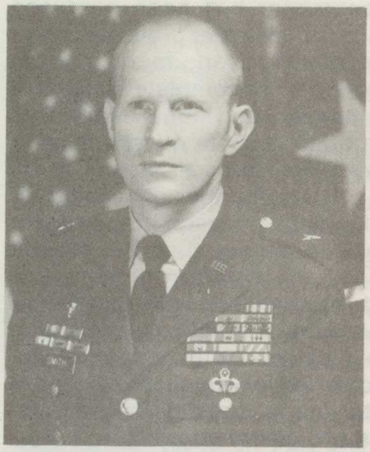


F.K. Fahmy.

Photo not available for C. Edwards.

Photo by Yvan Gagné

Brigadier General Scott B. Smith assumed command of the North Central Division, U.S. Army Corps of Engineers on 1 December, 1980. Smith, formerly Assistant Division Commander, 7th Infantry Division, Fort Ord, California, succeeds Major General Richard L. Harris, who is retiring from the Army.



Brigadier General Scott B. Smith

(U.S. Army photo - Eric Anderson, photographer).

As North Central Division Engineer, headquartered in Chicago, General Smith will direct civil works activities in a 428,000 square-mile area that includes the Great Lakes and Upper Mississippi River basins. He also will supervise Corps activities related to agreements between the United States and Canada on the regulation of boundary waters by serving on six advisory boards to the International Joint Commission. He will serve as a Commissioner on the Great Lakes Basin Commission and on the Upper Mississippi River Basin Commission.

DIOXIN

Dioxin is the name of a group of 75 chemicals of the chlorinated dibenzodioxin family. One member of the family -- 2,3,7,8 tetrachlorodibenzo-para-dioxin, or TCDD -- is extremely dangerous. To some mammals it is 500 times more deadly than strychnine and 1,000 times more lethal than cyanide. Small doses can cause skin irritations, or damage livers, spleens, central nervous systems, the pancreas, brains or lungs and can cause birth defects. TCDD can pass directly through the skin to act on the internal systems of animals and people.

TCDD is not manufactured on purpose. It is an unwanted by-product of the manufacture of certain other chemical compounds, for example, pentachlorophenol and 2,4,5-T. At the IJC's Annual Meeting on Great Lakes Water Quality, Dr. Andy Robertson of the Aquatic Ecosystem Objectives Committee and the National Oceanic and Atmospheric Administration, told the Commission that TCDD is also "a contaminant in incineration of municipal and other wastes containing organochlorine compounds."

The presence of dioxins is measured in parts per trillion. One part per trillion corresponds to one second in 30,000 years. It is difficult to comprehend that so small a quantity can be dangerous. Yet, once dioxin is present in any amount it can accumulate and affect the health of animals and people.

The acutely toxic chemical dioxin has been found in gull eggs collected throughout the Great Lakes. Dr. Douglas Hallett, Canadian Wildlife Service researcher, reported early in December 1980 results of tests of eggs collected over the past 10 years but kept frozen until testing procedures had been proven. He had found the dioxin last August, but his research was not announced until Agriculture Canada and the U.S. Environmental Protection Agency confirmed it in separate tests.

The U.S. EPA criterion for dioxin in drinking water simply states there should be none; there is no safe level for the chemical. Canadian guidelines do not list a dioxin criterion.

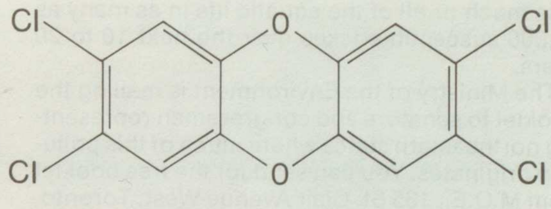
Levels of dioxin in the gull eggs are declining. The highest levels were found in samples taken from Lake Ontario in 1971: 800 parts per trillion. Levels found in 1980 samples fell to between 44 and 64 parts per trillion.

A June 1980 U.S. EPA report on dioxins named Hooker Chemical and Plastics Corporation of Niagara Falls as the only Lake Ontario producer of trichlorophenols (TCP), a building block of dioxin. Hooker's production ended in 1974. Olin Corporation, also of Niagara Falls, is said to have disposed of 65 tons of dioxin-contaminated TCP and benzene hexachloride (a TCP building block), according to the U.S. Government's 1979 lawsuit. A New York State report points to the Love Canal site and an even larger one, Hyde Park, as the two major sources from which dioxin is leaching.

On December 2, 1980, Canada's Environment Minister John Roberts asked the U.S. Government to investigate the dioxin problem and to take action once the sources are identified.

Few laboratories are equipped to handle dioxins. Not only are the analytical methods complex, the amounts of materials being sought are so small that the entire laboratory must be in ultraclean condition at all times so that samples are not contaminated. Further, the safety precautions must be extensive. The safety and cleaning procedures must outdo those of an operating room. Ontario's Ministry of the Environment recently established such a laboratory in Rexdale, Ontario.

The Aquatic Ecosystem Objectives Committee spokesman, Dr. Robertson, stated that unfortunately, for most members of the dioxin family, there are inadequate data. For TCDD, however, the Committee does believe there is enough information. In the Committee report, members recommend "that this material be absent from all components of the ecosystem including air, land, water, sediment and biota. Absent means not detectable as determined by the best available technology." -- however advanced that technology becomes. The present detection limits for TCDD are 0.01 μg/kg in tissue and sediment and 0.00001 μg/L in water.



TCDD

BOOKSHELF

Many reports were issued by the boards and their committees at the November Annual Meeting on the Great Lakes Water Quality Agreement. All are available from the Great Lakes Regional Office of the Commission, 100 Ouellette Avenue, Windsor, Ontario N9A 6T3 or telephone (313) 963-9041-United States; (519) 256-7821-Canada. The documents released include the annual reports of the Water Quality Board and the Science Advisory Board (A Perspective on the problem of hazardous substances in the Great Lakes Basin Ecosystem), and publications by the Toxic Substances Committee, Health Effects Committee, Task Force on Non NTA Detergent Builders, and the Aquatic Ecosystem Objectives Committee. In addition, both boards' reports had appendix volumes. The Water Quality Board Appendix contains data used to form the Board's conclusions. The Science Advisory Board Appendix contains four background reports used in the development of this year's summary volume; three of them concern atmospheric deposition and the fourth report deals with toxic substances in wastewaters.

"The Case Against the Rain", is a new, well illustrated booklet published by Ontario's Ministry of the Environment (MOE). It explains the nature and magnitude of acidic precipitation throughout eastern North America, describes the extent of the acid rain problem in Ontario, outlines the programs which the Province has underway to meet the challenge, and states the need for action in the United States and Canada to curb acid rain pollution.

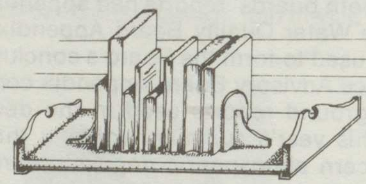
Should action not be taken to reduce acidic loadings, scientists estimate that Ontario could lose much or all of the aquatic life in as many as 48,000 susceptible lakes over the next 10 to 20 years.

The Ministry of the Environment is mailing the booklet to senators and congressmen representing northeastern states where much of this pollution originates. You can send for the free booklet from M.O.E., 135 St. Clair Avenue West, Toronto, Ontario M4V 1P5.

A 95-page technical bibliography, "The Long Range Transport of Air Pollutants and Acidic Precipitation", jointly prepared by the Ontario Ministry of the Environment and Environment Canada's Atmospheric Environment Service is available for $5. Mail cheques in Canadian funds made payable to: "Treasurer of Ontario" with requests addressed to: Publications Centre, Ministry of Government Services, 5th Floor, 880 Bay Street, Toronto, Ontario M7A 1N8 or to "Receiver General for Canada", addressed to LRTAP Progress Office, A E S - Environment Canada, 4905 Dufferin Street, Downsview, Ontario M3H 5T4.

"Waste Facility Siting -- A public dilemma", is a speech Tom Williams, Assistant to the Director, Office of Public Awareness, U.S. Environmental Protection Agency, presented at the League of Women Voters Seminar on Improving Citizen Participation in Waste Facility Siting in October, 1980. In his talk Mr. Williams clearly explains the problems of siting as perceived by the public and government. For a copy write the U.S. Environmental Protection Agency, Office of Public Awareness, 401 M. Street S.W., Washington, D.C.

Bookshelf continued on page 16.



USE OF WATER QUALITY INDICES ON LAKES

by Nina I. McClelland and Rolf A. Deininger

Indices - why are they needed?

"When you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of meager and unsatisfactory kind." (Lord Kelvin, 1889)

In 1965, the Environmental Pollution Panel of the President's Science Advisory Committee recommended, "That the Federal Government stimulate development of a method for assigning a numerical index of chemical pollution to water samples. The method should be sensitive to most chemical pollutants, and its results should be roughly proportional to the unfavorable effects of the pollution on man or aquatic life. Such an index will allow us to follow many important changes in general water quality in a way similar to that in which the coliform count [enables us to track changes in] pollution by untreated sewage."

The *1972 Annual Report* of the Council on Environmental Quality[1] states that, "Accurate and timely information on status and trends in the environment is necessary to shape sound public policy and to implement environmental quality programs efficiently". It continues, "One of the most effective ways to communicate information on environmental trends to policy makers and the general public is with indices".

A 1975 report by the National Academy of Sciences[2] indicated that, despite the need for such indices, progress for their development had been unsatisfactory.

> "Environmental indices provide an important method for evaluating the state of the environment. Despite strong statements of need from all three branches of government, progress toward the environmental quality has not been satisfactory."

Furthermore, they wrote:

> "There appear to be no insurmountable obstacles to development of useful water quality indices and the committee recommends their prompt construction and use."

There is still no generally accepted index of the water quality for lakes. What is needed are objective, reliable, repeatable, and uniform methods for assessing water quality which reflect the composite influence of the individually measureable parameters. Such indices would properly inform the public about the magnitude of the water quality problems, their rates of improvement or degradation, identify critical regions, indicate the effectiveness of abatement programs, and help to establish priorities for abatement strategies.

Indices of the past

The concept of developing a single numerical quantity to describe the quality of a lake has been attractive in Europe. Several investigators have attempted to define such an index. One of the earliest efforts is represented by the saprobic system, published by Kolkwitz and Marson in 1908[3]. Basically, this system is a biological index, dividing water into three classes according to the occurrence of indicator organisms. Aquatic biologists have never been happy with this index because of its large built-in subjectivity, and its frequent misuse by unqualified persons. Later, the saprobic system was expanded to include four classes; and, in 1955, Pandtle and Buck[4] suggested a numerical rating of each saprobic zone. A rating of 1 to 1.5 denoted the oligosaprobic zone; 1.5 to 2.5 denoted the *a*-mesaprobic zone; 2.4 to 3.5, the *b*-mesosaprobic zone; and 3.5 to 4.0, the polysaprobic zone. There have been more recent attempts to develop a new, nine-class saprobic system, notably by Fierdingstad (1971)[5]; but these systems have not been widely accepted. A more promising approach appears to be the use of diversity indices. This concept circumvents the use of indicator organisms and establishes an index based on the distribution of species found in the water or in bottom samples. A summary of the various types of diversity indices proposed to date is found in a publication by Wilhm (1972)[6].

Traditionally, lake water quality has been categorized in terms of its trophic state: oligotrophic, mesotrophic, eutrophic. Recently, additional states; i.e., ultra-oligotrophic and hypereutrophic, have been added to increase the discrimination. The trophic state is determined by a variety of diverse criteria, such as the shape of the oxygen curve, the species composition of the bottom fauna or phytoplankton, concentrations of nutrients, and various measures of biomass and production. Although measures of each of these parameters tend to vary with the trophic status of a water body, the changes do not occur at sharply defined places; and some lakes may be classified as oligotrophic by one criterion (parameter), and eutrophic by another.

Some researchers have tried to relate the trophic status of a lake to the chlorophyll *a* concentration, as shown in the Table I. More recently, the National Eutrophication Survey (NES) of the Environmental Protection Agency[10] developed further guidelines for determining the trophic state based on the values of three parameters, as shown in Table II.

Again, NES[10] developed a "trophic index" by calculating the sum of the percentile rankings of more than 200 lakes, based on six parameters of water quality; i.e., total phosphorus, dissolved phosphorus, inorganic nitrogen, dissolved oxygen, secchi disk depth, and chlorophyll *a*. This index can vary from 594 to zero; the arbitrary assigned corresponding trophic states are indicated in Table IV.

TABLE I. RELATIONSHIP BETWEEN CHLOROPHYLL a AND TROPHIC CONDITION

Lake Condition	Chlorophyll a (μg/L) Sakamoto (1966)[7]	National Academy of Science (1972)[8]	Dobson (1974)[9]
Oligotrophic	.3-2.5	0-4	0-4.3
Mesotrophic	1-15	4-10	4.3-8.8
Eutrophic	5-140	>10	>8.8

Dobson (1974)[9] proposed a "water quality scale" based on four parameters, shown in Table III.

TABLE II. SINGLE PARAMETERS AS INDICATORS OF THE TROPHIC STATE

Trophic State	Chlorophyll a (μg/L)	Total Phosphorus (μg/L)	Secchi Disk
Oligotrophic	7	10	greater than 3.7 meters
Mesotrophic	7-12	10-20	greater than 2.0 meters
Eutrophic	12	20	less than 2.0 meters

TABLE III. RELATIONSHIP OF FOUR PARAMETERS TO LAKE CONDITION

Measure	Trophic State: Low	Medium	High
Secchi depth	0-4.9 (m-1x30)	5.0-9.9 (m- x30)	10.0 and up (m- x30)
Chlorophyll a	0-4.3 (ug/litre)	4.4-8.7 (ug/litre)	8.8 and up (ug/litre)
Particulates	0-270 (μg P/litre)	280-550 (μg P/litre)	560 and up (μg P/litre)

TABLE IV. NES TROPHIC STATE VERSUS TROPHIC INDEX

Trophic States	Trophic Index Number
Oligotrophic	500-594
Mesotrophic	420-499
Eutrophic	below 420

There is growing concern that neither a biological nor a chemical water quality index alone is adequate, but that all parameters must be considered simultaneously. In a publication by Liebman (1969)[11], such an approach is shown. Chemical and saprobic indices are given equal weight in an overall water quality index.

A relatively recent and complete review of water quality indices is contained in the doctoral dissertation of Landwehr (1974)[12]. A review of water quality indices by Orlando (1976)[13] for the Council on Environmental Quality includes the same literature, and a survey by Ott (1977)[14] indicates the variety of indices used in the United States with major emphasis on the indices for rivers.

What emerges is that, at present, there is not agreement on which set of parameters of water quality should be considered an index for lacustrine conditions, what their significance (or relative importance) is, and what kind of overall index formulation should be used.

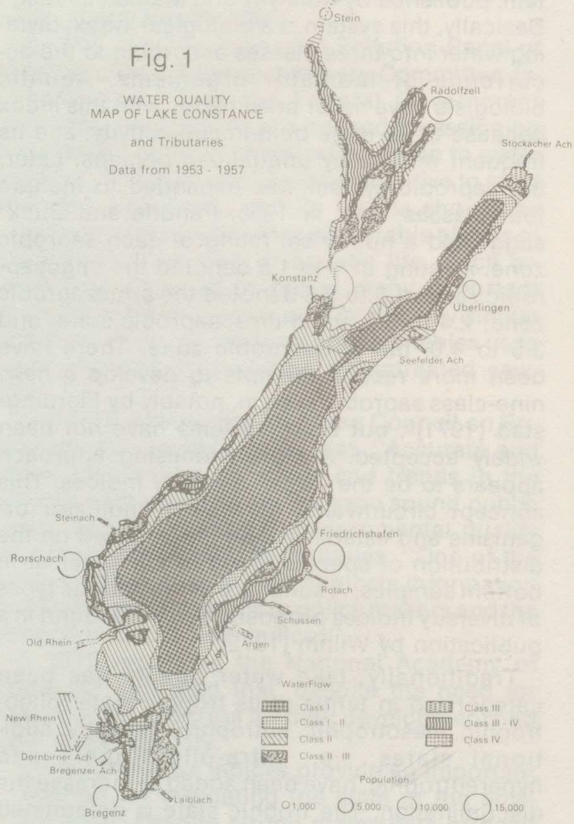
To demonstrate what can be done with a water quality index, refer to Figure 1. The water quality of Lake Constance is charted according to Liebman's method[11]. This lake is at the borders of three countries: Germany, Switzerland, and Austria. The influence and affect of the individual tributaries and cities is clearly shown, and the aerial extent of damages to the lake is visible and understandable.

This map of water quality was communicated to legislators, and the net result was heavy public investments in intercepting sewers and treatment plants. If this lake were graphed today, it would indicate the tremendous improvement in water quality. Without such a comprehensive mapping, it is doubtful that legislators could have been convinced of the value of the investment. One example of how water quality is portrayed today in the United States is available from a recent publication of the IJC Great Lakes Water Quality Board (see Figure 2)[15].

What really is needed is a way to show cause and effect; that is, the quality of a lake must be related to the quality of the rivers and tributaries discharging into the lake. Theoretically, the index used to describe the quality of rivers should also be applicable to lakes. If it is not, the quality of the same water would be described differently as a function of location only.

The Water Quality Index (WQI)[16] developed by the National Sanitation Foundation (NSF) is currently the most widely used index. One out of every six of the United States is using WQI, as well as Scotland, Australia, Brazil, and Spain. Both verbal and graphic descriptors have been developed for WQI and are used by Michigan and New York in their annual Water Quality Inventory Reports to the U.S. Congress[17,18].

Certainly WQI, the NES Trophic State Index, Dobson's Water Quality Scale[9], and Shannon's Trophic Index Number[19] qualify as candidates for lake applications. Comparison using historical

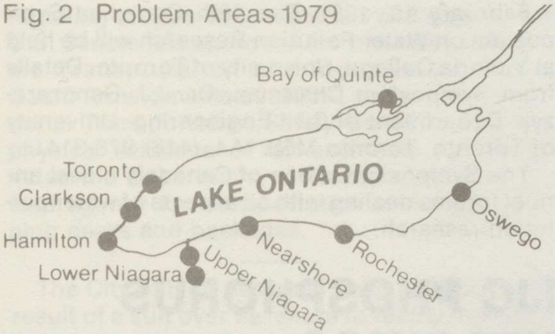


data from the Great Lakes is a logical first step in establishing feasibility of any or all of these established water quality reporting systems. If necessary, new indices could be developed and might include more - or different - parameters than those reflected in currently available indices. A list of potential parameters is shown in Table V. Group rather than individual opinion is recommended for the selection process as well as subsequent decision; i.e., the ultimate empirical form of the index expression.

Table V Potential Parameters for a Water Quality Index for Lakes

nitrogen (organic & inorganic)	turbidity
phosphorus (total & dissolved)	temperature
total cell volume	alkalinity
primary productivity	carbon (TOC)
coliform organisms	pH
chlorophyll a	hardness
fecal coliforms	color
fecal streptococci	solids
toxic substances	secchi disk
chemical oxygen demand	conductivity
dissolved oxygen	
biochemical oxygen demand	
biological parameters	
carbon chloroform extract	
inorganic ions (Ca, Mg, Cl, Si, K, Na, Mn)	

Fig. 2 Problem Areas 1979



There is no question that an index system validated for lakes is desirable for water quality trend reporting and for legislative decision making. But, before a new index - or family of indices - is adopted, the feasibility of using an existing index should be carefully examined to assure standardized reporting to the greatest extent possible.

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BEACHED BIRD SURVEY

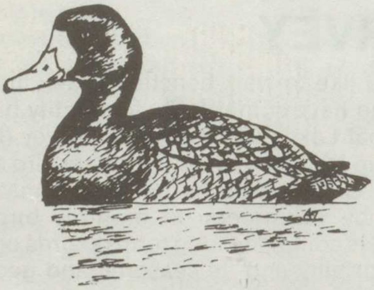
If you like to walk beaches at any time of the year and have some ability to identify birds, join the Great Lakes Beached Bird Survey (GLBBS). Begun in 1977, the survey monitors bird mortality on the Great Lakes by using information collected by volunteers on monthly bird walks. GLBBS is compiling long term records on natural bird mortality and its seasonal and geographic patterns to help assess the significance of bird die-offs and to learn more about the effects of pollutants on birds. It also documents the occurrence of uncommon species like jaegers and eiders.

In 1979, 1,416 birds of 102 species were found in 54 routes that comprised 1.2% of the Great Lakes shoreline (188 km or 111.7 miles). The average number of birds found was 1.14 per km or 1.84 per mile. Since 1977, 129 species have been represented as beached birds.

As in the survey's first year, Ring-billed Gulls and Herring Gulls made up about half of beached birds found. Data on the age of gulls found show that the majority were hatching year birds. The cause of death was reported for 9% of beached birds, with apparent starvation listed most frequently. The seasonal pattern of beached bird numbers was examined. Numbers of all beached birds peaked in spring and fall, but variations in the general pattern were noted for different types of birds.

Here are some examples of the survey's findings: seasonal patterns of mortality characteristic of different groups of birds; a large variety of natural and man-related causes of death, including an oil spill; large die-offs of migrating passerines in spring following periods of severe weather; age ratios of beached gulls; high mortality levels of some species such as Oldsqaw and White-winged Scoters. Survey results are published in an annual report and a newsletter sent to all beach walkers.

Counts of live waterbirds are also done at many survey routes to help in the survey's examination of the effects of winter shipping and ice conditions on bird numbers and distribution. There is a special invitation for people to make live waterbird counts at urban harbors even though they may lack beaches suitable for survey walks. New participants are still needed on any of the Great Lakes or connecting rivers, particularly on the south shore of Lake Ontario and the St. Marys River. If you are interested in taking part, write to: Anne Lambert, Great Lakes Beached Bird Survey, c/o Long Point Bird Observatory, P.O. Box 160, Port Rowan, Ontario, Canada N0E 1M0.



EVENTS

The Pollution Control Association of Ontario is cosponsoring two events of possible interest.

With the Ministry of the Environment at the Ministry of Health Laboratory: Seminar on solutions for industrial waste siting - March 11, 1981. With Air Pollution Control Association at the Holiday Inn, Sudbury, Ontario: Annual Conference, May 3-6, 1981. For more about either event, contact Mrs. S. Davey, P.O. Box 790, Oak Ridges, Ontario, L0G 1P0 (416) 773-4124.

A conference entitled "The Effects of Acid Precipitation on Ecological Systems in the Great Lakes Region of the United States" will be held at Michigan State University's Kellogg Conference Center on April 1-3, 1981. In a multidisciplinary forum, 25 scientists will exchange information on sources, monitoring and the resultant effects on aquatic and terrestrial ecosystems. The participants will also identify research needs and suggest priorities among them. For more information, contact Howard Bernson, Conference Coordinator, University Conference and Institutes, 49 Kellogg Center, MSU, East Lansing, MI 48824, or telephone (517) 355-4557.

February 19, 1981. The 16th Canadian Symposium on Water Pollution Research will be held at Victoria College, University of Toronto. Details from Symposium Chairman, Dr. J.J. Ganczarczyk, Department of Civil Engineering, University of Toronto, Toronto M5S 1A4. (416) 978-3141.

The Symposium is one of Canada's oldest annual forums dealing with all aspects of water pollution research.

IJC PHOSPHORUS HEARINGS

The International Joint Commission held public hearings on the topic of phosphorus management strategies for the Great Lakes November 19 at Windsor, Ontario, and November 20 at Buffalo, New York. Immediately following the hearings, the IJC staff began drafting a report to the Governments of Canada and the United States. At the hearings, the IJC was requested by the Governments to submit that report by the end of January, 1981.

The purpose of the hearings was to obtain comments from the public after the Commission received the report and recommendations of its special task force on phosphorus management strategies. (See *Focus* 6-3, October, 1980.)

The task force was formed to develop data to assist the Commission make recommendations to the Governments for setting phosphorus target loads for the Great Lakes as required by the 1978 Great Lakes Water Quality Agreement. The Governments have set a deadline of May 31, 1981 for announcing the target loads.

Elizabeth Hoffman, Mayor of North Tonawanda, said there are enough rules and regulations.

Gordon Van Fleet, of the Ontario Ministry of the Environment, presented the Task Force Report.

LAW AND THE COURTS

Both the United States Environmental Protection Agency and the Department of Transportation have issued new regulations governing the handling of hazardous materials and wastes. The U.S. Senate has approved the Hazardous Materials Transportation and Independent Safety Board Amendments of 1980. It authorizes the National Transportation Safety Board to examine physical evidence of rail accidents and designates the Department of Transportation as the lead agency for transportation of nuclear shipping casks and packages.

The City of Flint has been fined $10,000 as the result of a suit over its failure to rectify defects in its wastewater treatment plant. Flint reached an agreement with state officials in January which outlined steps the city was to take to stop discharges from its plant, but a county judge ruled that the agreement was not met between February 1 and April 9. Violation of the agreement could have carried a fine of $10,000 per day. Penalty is believed to be the first of its kind levied against a Michigan city. (*Air/water pollution report*, June 30, 1980).

National Steel Corporation's Detroit plant is one of the three that company will bring into compliance with all air and water pollution control requirements by the end of 1982. U.S.-EPA's settlement with the company incorporates upgrading several basic steelmaking processes. EPA stated that the health of persons near the plants will be protected as will the economic stability of the facilities. Fines for the past violations will be offset with more pollution control than would otherwise have been required (*Air/Water Pollution Report* November 10, 1980).

In November the United States Senate passed a "Superfund" bill. Quickly comprises were worked out between that version and the House of Representative's version, and before Christmas President Carter signed the bill into law. The money is to be used to clean up inactive hazardous waste disposal sites and chemical spills on land, into navigable waters or affecting groundwater.

The Ontario Ministry of the Environment is hiring 13 people who will be trained in investigation techniques to serve as a special environmental police unit to enforce Ontario's environmental laws.

This fall legislation was introduced to amend existing environmental regulations, to set minimum fines for illegal liquid waste dumping and handling. The amendments also empower the Ministry to seize and impound any vehicle involved in the illegal activity. In addition, two new positions are being filled in the Ministry's legal services branch to handle the increased number of prosecutions and control orders. The special investigation unit will act to prevent serious pollution incidents by carrying out spot audits and special checks of industrial, commercial and municipal records and activities. A large part of the unit's work will involve investigations into illegal dumping of liquid industrial waste.

The investigators will operate from Ministry regional offices in Toronto, Hamilton-Niagara, Sudbury, Thunder Bay, London and Kingston.

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Jacques Cousteau and Mayor Coleman Young of the City of Detroit answered questions from some of the 5,000 plus people who greeted the explorer when he visited Detroit during his recent filming trip through the Great Lakes.

Photo by Yvan Gagné

THINGS TO SEE

A new 16mm, 38 minute film in sound and color has been completed describing research supported by the National Science Foundation on the use of wetlands as an alternative to conventional methods of advanced or tertiary treatment of wastewater. "Wetlands - Our Natural Partners in Wastewater Management" documents research completed and underway on this innovative concept and suggests directions for further studies to seek a better understanding of the potentially larger role that wetlands can play in management of the nutrient and water content of wastewaters.

The film describes basic and applied research that led to the current, full-scale, proof-of-concept experiment of the Houghton Lake (Michigan) Sewer Authority in which the community's oxidation pond effluent is being placed into a natural wetland. The effluent's content of nitrogen and phosphorus is utilized by wetland vegetation, thus increasing the wetland's productivity. At another Michigan location near Vermontville, a wastewater management site that was designed for land-application